Earthquake Energy Scaling Workshop

July 24, 2003
Wente Vinyards
Livermore, California

Sponsored by IGPP/LLNL
Rick Ryerson, Geosciences Center Head

Hosted by Bill Walter and Kevin Mayeda
Lab-Wide LDRD Project

Intro

- **Welcome and Acknowledgements**

- **Logistics and Agenda**
  - **- Agenda and dinner sign-up sheet**
  - **- Planned Format: talks with questions and comments/viewgraphs**
  - **- Projectors**

- **Issues, Poll Results and Questions to be Addressed**

Meetings Focused On Energy Scaling

- Fall 2002 Special Session
- Summer 2003 Earthquake Energy Scaling Workshop
- Summer 2004? Chapman Conference

Basic Seismic Measures of Earthquake Scaling

Static - Mo

M_o= □ (avg. slip) (fault area)

Very accurate quantitative seismic measures

Dynamic - Es

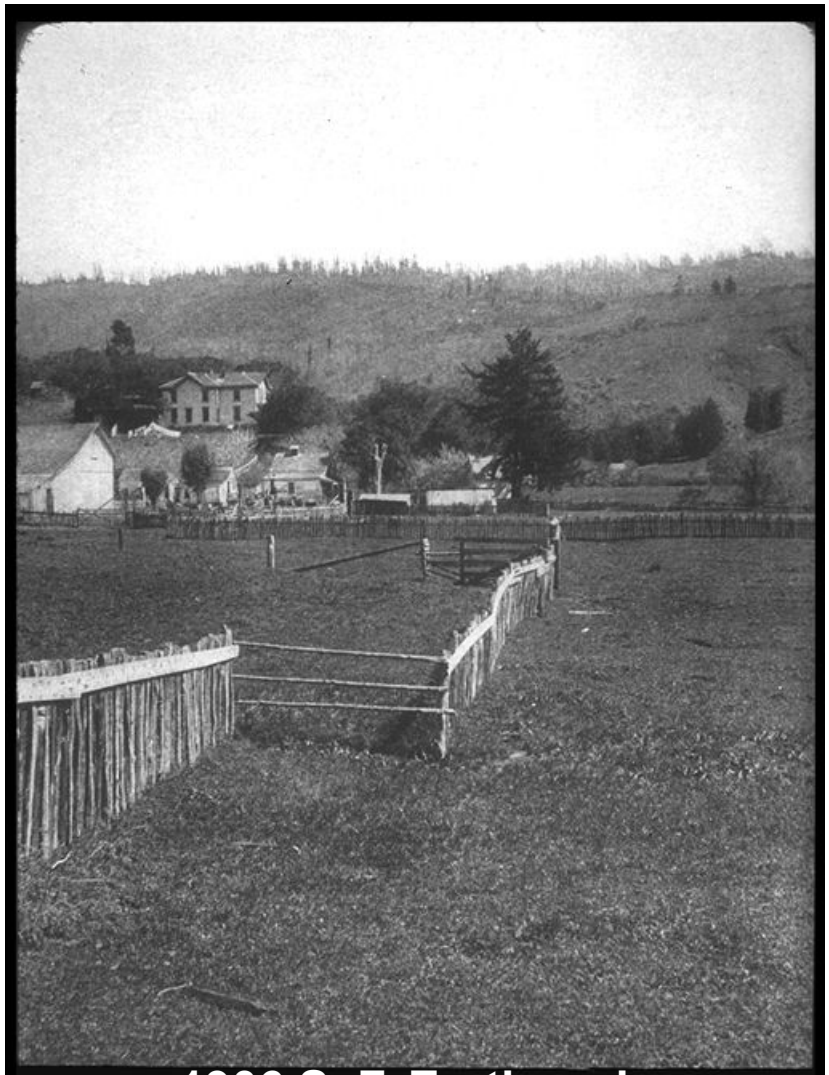
E_s = □ (avg. slip) (fault area)

Seismic measures require many corrections

Apparent Stress ~ Dynamic/Static

□ = □E_s/M_o

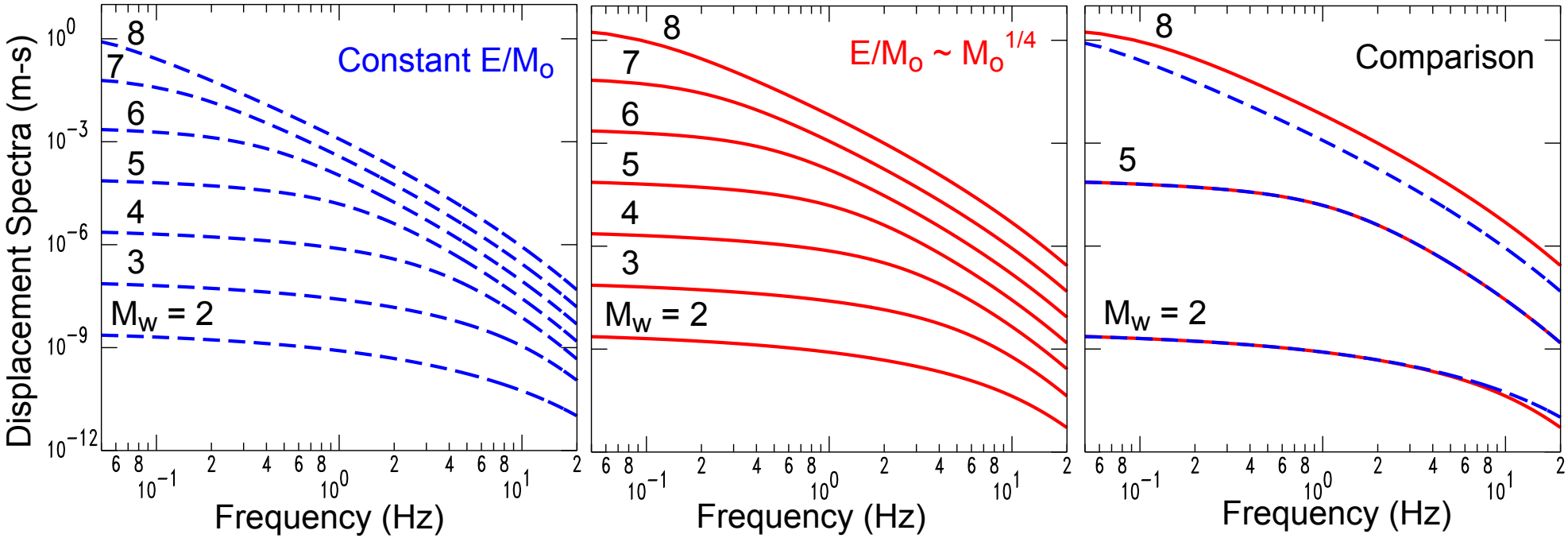
Main uncertainties from seismic energy estimates



1906 S. F. Earthquake
2.5 m offset near Bolinas
(photo by C.K. Gilbert)

Comparing spectra shows the difficulty in distinguishing between the two cases at small Mw and differences in extrapolation at large Mw

Model spectra calculated using MDAC2 code for Western U.S. parameters

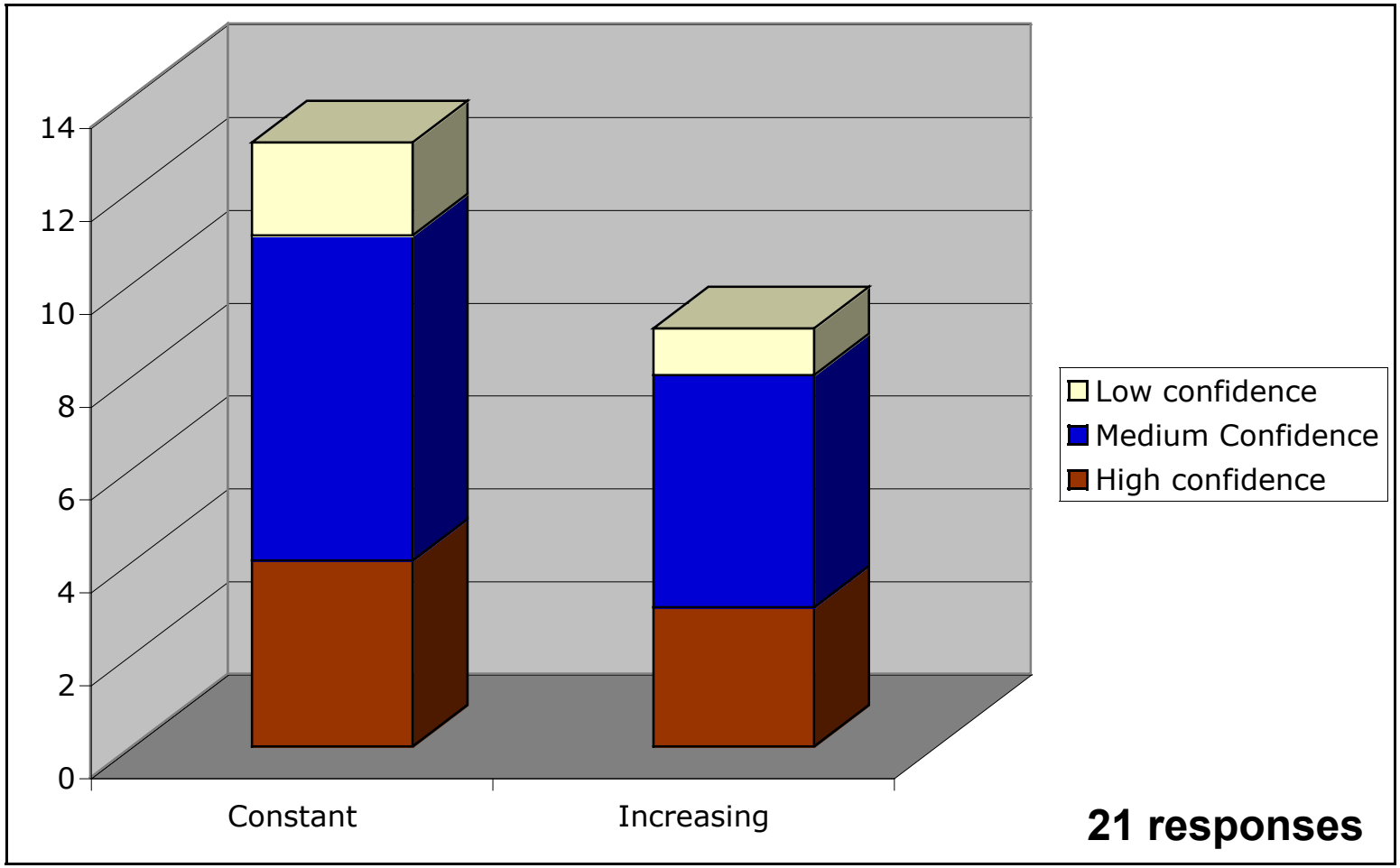


- **Differences for small events occur at high frequencies where attenuation corrections are large.**

- **Large events have big differences, but there are fewer of these well-recorded at local and regional distances. Teleseismic measures require significant corrections.**

Workshop Poll Results Show a Split

If forced to chose, do you believe that the available evidence shows:
1) Earthquake Es/Mo scaling is generally constant or increasing over Mw 1 to 8?
2) Is your confidence level high, medium or low?

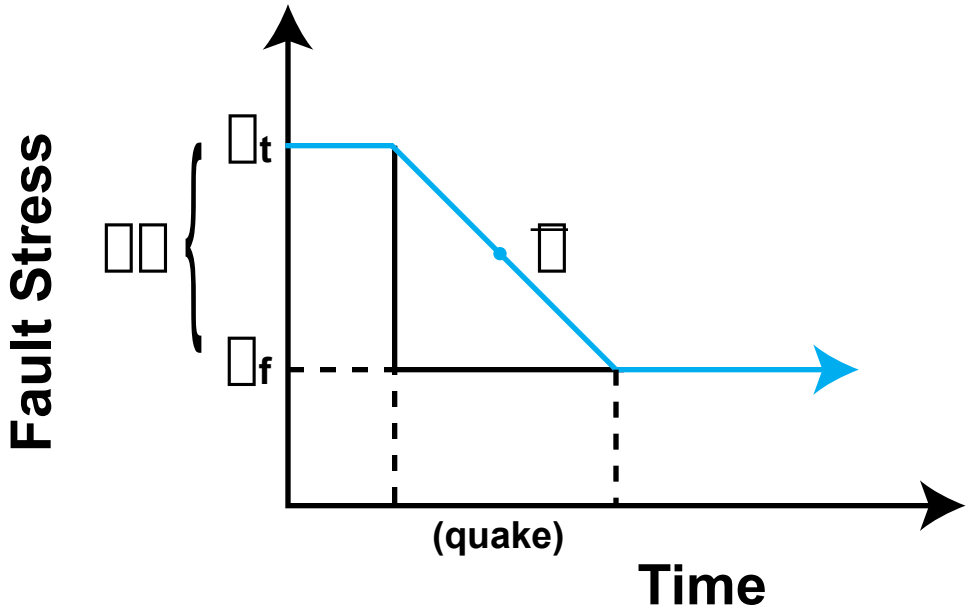


Apparent Stress Scaling Has Implications for Earthquake Physics

Consider a simple fault model of Orowan (1960) where the available elastic energy is partitioned into seismic and non-seismic portions depending on the efficiency:

E_e = □ (avg. slip) (area) Elastic Energy
E_f = □$_f$ (avg. slip) (area) Frictional Energy
E_s = □ (avg. slip) (area) Seismic Energy

E_s = □E_e = E_e - E_f (□ is the efficiency)
□ = □□ = □□/2 (Apparent stress, Wyss, 1970); Tie between □ and □□ is model dependent!



Implications:

1) absolute stress values are not observed seismically

2) variable efficiency implies variable tectonic and/or frictional stress levels

Workshop Questions

- What is the scaling behavior of earthquake seismic energy with moment? (e.g. constant apparent stress (E_S/M_O), increasing, other?)

- What earthquake physics is implied by these apparent stress models?

- What is the level of variability of seismic energy for a given moment and where does this variability come from?

- Can we reach consensus on seismic energy from teleseismic, regional, borehole, and mine estimates?